

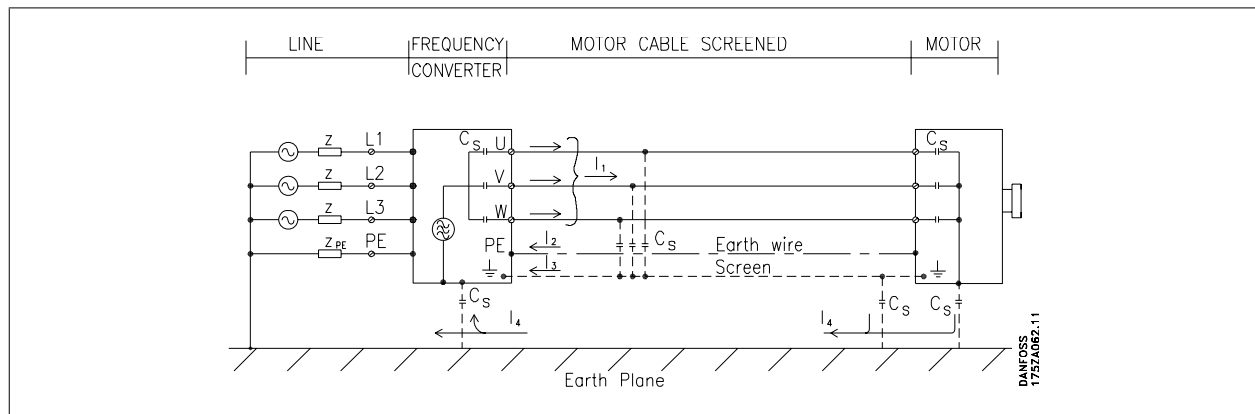
2.9 General Aspects of EMC

2.9.1 General Aspects of EMC Emissions

Electrical interference is usually conducted at frequencies in the range 150 kHz to 30 MHz. Airborne interference from the drive system in the range 30 MHz to 1 GHz is generated from the inverter, motor cable, and the motor.

As shown in the illustration below, capacitive currents in the motor cable coupled with a high dV/dt from the motor voltage generate leakage currents. The use of a screened motor cable increases the leakage current (see illustration below) because screened cables have higher capacitance to earth than unscreened cables. If the leakage current is not filtered, it will cause greater interference on the mains in the radio frequency range below approximately 5 MHz. Since the leakage current (I_1) is carried back to the unit through the screen (I_3), there will in principle only be a small electro-magnetic field (I_4) from the screened motor cable according to the below figure.

The screen reduces the radiated interference but increases the low-frequency interference on the mains. The motor cable screen must be connected to the frequency converter enclosure as well as on the motor enclosure. This is best done by using integrated screen clamps so as to avoid twisted screen ends (pigtailed). These increase the screen impedance at higher frequencies, which reduces the screen effect and increases the leakage current (I_4). If a screened cable is used for fieldbus, relay, control cable, signal interface and brake, the screen must be mounted on the enclosure at both ends. In some situations, however, it will be necessary to break the screen to avoid current loops.



If the screen is to be placed on a mounting plate for the frequency converter, the mounting plate must be made of metal, because the screen currents have to be conveyed back to the unit. Moreover, ensure good electrical contact from the mounting plate through the mounting screws to the frequency converter chassis.

When unscreened cables are used, some emission requirements are not complied with, although the immunity requirements are observed.

In order to reduce the interference level from the entire system (unit + installation), make motor and brake cables as short as possible. Avoid placing cables with a sensitive signal level alongside motor and brake cables. Radio interference higher than 50 MHz (airborne) is especially generated by the control electronics.

2.9.2 Emission Requirements

According to the EMC product standard for adjustable speed frequency converters EN/IEC61800-3:2004 the EMC requirements depend on the intended use of the frequency converter. Four categories are defined in the EMC product standard. The definitions of the four categories together with the requirements for mains supply voltage conducted emissions are given in the table below:

Category	Definition	Conducted emission requirement according to the limits given in EN55011
C1	frequency converters installed in the first environment (home and office) with a supply voltage less than 1000 V.	Class B
C2	frequency converters installed in the first environment (home and office) with a supply voltage less than 1000 V, which are neither plug-in nor movable and are intended to be installed and commissioned by a professional.	Class A Group 1
C3	frequency converters installed in the second environment (industrial) with a supply voltage lower than 1000 V.	Class A Group 2
C4	frequency converters installed in the second environment with a supply voltage equal to or above 1000 V or rated current equal to or above 400 A or intended for use in complex systems.	No limit line. An EMC plan should be made.

When the generic emission standards are used the frequency converters are required to comply with the following limits:

Environment	Generic standard	Conducted emission requirement according to the limits given in EN55011
First environment (home and office)	EN/IEC61000-6-3 Emission standard for residential, commercial and light industrial environments.	Class B
Second environment (industrial environment)	EN/IEC61000-6-4 Emission standard for industrial environments.	Class A Group 1

2.9.3 EMC Test Results (Emission)

The following test results have been obtained using a system with a frequency converter (with options if relevant), a screened control cable, a control box with potentiometer, as well as a motor and motor screened cable.

RFI filter type	Conducted emission. Maximum shielded cable length.			Radiated emission		
	Industrial environment	Housing, trades and light industries	Industrial environment	Housing, trades and light industries		
Standard	EN 55011 Class A2	EN 55011 Class A1	EN 55011 Class B	EN 55011 Class A1	EN 55011 Class B	
H1						
1.1-45 kW 200-240 V	T2	150 m	150 m	50 m	Yes	No
1.1-90 kW 380-480 V	T4	150 m	150 m	50 m	Yes	No
H2						
1.1-3.7 kW 200-240 V	T2	5 m	No	No	No	No
5.5-45 kW 200-240 V	T2	25 m	No	No	No	No
1.1-7.5 kW 380-480 V	T4	5 m	No	No	No	No
11-90 kW 380-480 V	T4	25 m	No	No	No	No
110-1000 kW 380-480 V	T4	150 m	No	No	No	No
45-1400 kW 525-690 V	T7	150 m	No	No	No	No
H3						
1.1-45 kW 200-240 V	T2	75 m	50 m	10 m	Yes	No
1.1-90 kW 380-480 V	T4	75 m	50 m	10 m	Yes	No
H4						
110-1000 kW 380-480 V	T4	150 m	150 m	No	Yes	No
45-400 kW 525-690 V	T7	150 m	30 m	No	No	No
Hx						
1.1-90 kW 525-600 V	T6	-	-	-	-	-

Table 2.1: EMC Test Results (Emission)

HX, H1, H2 or H3 is defined in the type code pos. 16 - 17 for EMC filters

HX - No EMC filters build in the frequency converter (600 V units only)

H1 - Integrated EMC filter. Fulfil Class A1/B

H2 - No additional EMC filter. Fulfil Class A2

H3 - Integrated EMC filter. Fulfil class A1/B (Frame size A1 only)

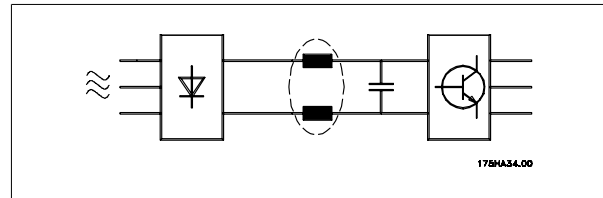
H4 - Integrated EMC filter. Fulfil class A1

2.9.4 General Aspects of Harmonics Emission

A frequency converter takes up a non-sinusoidal current from mains, which increases the input current I_{RMS} . A non-sinusoidal current is transformed by means of a Fourier analysis and split up into sine-wave currents with different frequencies, i.e. different harmonic currents I_N with 50 Hz as the basic frequency:

Harmonic currents	I_1	I_5	I_7
Hz	50 Hz	250 Hz	350 Hz

The harmonics do not affect the power consumption directly but increase the heat losses in the installation (transformer, cables). Consequently, in plants with a high percentage of rectifier load, maintain harmonic currents at a low level to avoid overload of the transformer and high temperature in the cables.



NB!
Some of the harmonic currents might disturb communication equipment connected to the same transformer or cause resonance in connection with power-factor correction batteries.

To ensure low harmonic currents, the frequency converter is equipped with intermediate circuit coils as standard. This normally reduces the input current I_{RMS} by 40%.

The voltage distortion on the mains supply voltage depends on the size of the harmonic currents multiplied by the mains impedance for the frequency in question. The total voltage distortion THD is calculated on the basis of the individual voltage harmonics using this formula:

$$THD \% = \sqrt{U_{\frac{2}{5}}^2 + U_{\frac{2}{7}}^2 + \dots + U_{\frac{2}{N}}^2} \quad (U_N\% \text{ of } U)$$

2.9.5 Harmonics Emission Requirements

Equipment connected to the public supply network:

Options:	Definition:
1	IEC/EN 61000-3-2 Class A for 3-phase balanced equipment (for professional equipment only up to 1 kW total power).
2	IEC/EN 61000-3-12 Equipment 16A-75A and professional equipment as from 1 kW up to 16A phase current.

2.9.6 Harmonics Test Results (Emission)

Power sizes up to PK75 in T2 and T4 complies with IEC/EN 61000-3-2 Class A. Power sizes from P1K1 and up to P18K in T2 and up to P90K in T4 complies with IEC/EN 61000-3-12, Table 4. Power sizes P110 - P450 in T4 also complies with IEC/EN 61000-3-12 even though not required because currents are above 75 A.

Provided that the short-circuit power of the supply S_{sc} is greater than or equal to:

$$S_{SC} = \sqrt{3} \times R_{SCE} \times U_{mains} \times I_{equ} = \sqrt{3} \times 120 \times 400 \times I_{equ}$$

at the interface point between the user's supply and the public system (R_{sce}).

It is the responsibility of the installer or user of the equipment to ensure, by consultation with the distribution network operator if necessary, that the equipment is connected only to a supply with a short-circuit power S_{sc} greater than or equal to specified above.

Other power sizes can be connected to the public supply network by consultation with the distribution network operator.

Compliance with various system level guidelines:

The harmonic current data in the table are given in accordance with IEC/EN61000-3-12 with reference to the Power Drive Systems product standard. They may be used as the basis for calculation of the harmonic currents' influence on the power supply system and for the documentation of compliance with relevant regional guidelines: IEEE 519 -1992; G5/4.

2

2.9.7 Immunity Requirements

The immunity requirements for frequency converters depend on the environment where they are installed. The requirements for the industrial environment are higher than the requirements for the home and office environment. All Armstrong frequency converters comply with the requirements for the industrial environment and consequently comply also with the lower requirements for home and office environment with a large safety margin.

In order to document immunity against electrical interference from electrical phenomena, the following immunity tests have been made on a system consisting of a frequency converter (with options if relevant), a screened control cable and a control box with potentiometer, motor cable and motor. The tests were performed in accordance with the following basic standards:

- **EN 61000-4-2 (IEC 61000-4-2):** Electrostatic discharges (ESD): Simulation of electrostatic discharges from human beings.
- **EN 61000-4-3 (IEC 61000-4-3):** Incoming electromagnetic field radiation, amplitude modulated simulation of the effects of radar and radio communication equipment as well as mobile communications equipment.
- **EN 61000-4-4 (IEC 61000-4-4):** Burst transients: Simulation of interference brought about by switching a contactor, relay or similar devices.
- **EN 61000-4-5 (IEC 61000-4-5):** Surge transients: Simulation of transients brought about e.g. by lightning that strikes near installations.
- **EN 61000-4-6 (IEC 61000-4-6):** RF Common mode: Simulation of the effect from radio-transmission equipment joined by connection cables.

See following EMC immunity form.

EMC immunity form

Voltage range: 200-240 V, 380-480 V					
Basic standard	Burst IEC 61000-4-4	Surge IEC 61000-4-5	ESD IEC 61000-4-2	Radiated electromagnetic field IEC 61000-4-3	RF common mode voltage IEC 61000-4-6
Acceptance criterion	B	B	B	A	A
Line	4 kV CM	2 kV/2 Ω DM 4 kV/12 Ω CM	—	—	10 V _{RMS}
Motor	4 kV CM	4 kV/2 Ω ¹⁾	—	—	10 V _{RMS}
Brake	4 kV CM	4 kV/2 Ω ¹⁾	—	—	10 V _{RMS}
Load sharing	4 kV CM	4 kV/2 Ω ¹⁾	—	—	10 V _{RMS}
Control wires	2 kV CM	2 kV/2 Ω ¹⁾	—	—	10 V _{RMS}
Standard bus	2 kV CM	2 kV/2 Ω ¹⁾	—	—	10 V _{RMS}
Relay wires	2 kV CM	2 kV/2 Ω ¹⁾	—	—	10 V _{RMS}
Application and Fieldbus options	2 kV CM	2 kV/2 Ω ¹⁾	—	—	10 V _{RMS}
LCP cable	2 kV CM	2 kV/2 Ω ¹⁾	—	—	10 V _{RMS}
External 24 V DC	2 kV CM	0.5 kV/2 Ω DM 1 kV/12 Ω CM	—	—	10 V _{RMS}
Enclosure	—	—	8 kV AD 6 kV CD	10 V/m	—

AD: Air Discharge
 CD: Contact Discharge
 CM: Common mode
 DM: Differential mode
 1. Injection on cable shield.

Table 2.2: Immunity